An Experimental Estimation of the Theory of Ancestral Contributions in Heredity.

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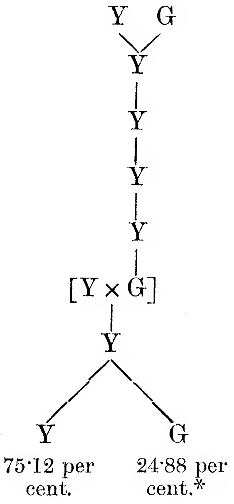
The experiments described in the following pages were undertaken with the object of finding out if the proportions in which characters segregate in the F_2 generation are affected by the distribution of those characters over the parentage and ancestry of the forms crossed. To this end I crossed a yellow pea with an extracted green in F_5, and obtained a purely negative result. The proportion of yellows and greens in the F_2 generation from this cross did not differ sensibly from that obtaining in the F_2 generation from a cross between a pure yellow and a pure green. The nature and result of the experiment may be summarised in the following pedigree, in which the two forms which I crossed are enclosed in brackets :—



DETAILS OF THE EXPERIMENT.

The Parent Forms.—(i) *The Greens.*

The original cross which provided me with the extracted F_5 greens used in my experiment was made by Mr. C. C. Hurst, and has been fully described by him.* In the spring of 1905, Mr. Hurst kindly sent me some seeds, the cotyledons of which belonged to the F_3 generation resulting from the cross which he had made. All the seeds were borne on a single plant (No. 31), of which the following is the pedigree, which is copied exactly from the MS. pedigree which Mr. Hurst sent to me with the seeds:—

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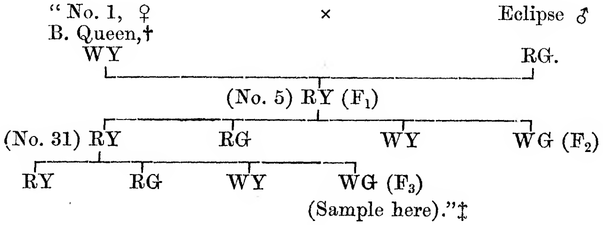
* See Summary on p. 78.



I sowed the yellow round seeds of the sample which Mr. Hurst sent me (*i.e.*, the YR cotyledoned plants of the F_3 generation) in the spring of 1905, and harvested F_4 in the autumn of that year. Of this F_4 generation only the YR were, as before, sown in the spring of 1906, and F_5§ was harvested in the autumn of that year. I kept some green round seeds from three plants of this generation, and it was this seed which produced the plants on which I made the crosses the results of which are recorded in this paper. The characters of these three plants are summarised in the following table, which gives the catalogue numbers of the parent plants and of the "green" plants‖ raised from their seeds, the numbers of the various kinds of seeds borne on the three parent plants, etc.:—

Catalogue numbers of—		Number of seeds borne by parent plant.				Number of green seeds sown.	Number of plants raised.
Parent plant.	Sowing of green seeds borne on it.	YR.	YW.	GR.	GW.		
B55.13	483	58	—	21	—	7	7
B54.180	484	29	9	7	2	6	5
B54.183	485	41	—	14	—	12	11

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* 'Journ. R. Horticultural Soc.,' vol. 28, pp. 483—494.

† British Queen.

‡ Y signifies yellow, G green, R round, and W wrinkled. Mr. Hurst writes the shape of the seed first. Throughout the present paper, however, the colour is written first.

§ The proportions of "yellows," "greens," "rounds," and "wrinkleds" in these generations will be published at a later date.

‖ By a "green" plant I mean one raised from a seed with green cotyledons.

(ii) *The Yellows.*

I shall now give a brief account of the various strains of yellow peas used in the experiment. I had been endeavouring for some time previous to 1907 to bring together a collection of peas from widely separated sources, with a view to repeating the observations of Mendel and others on a broader basis of material. The yellow strains thus obtained were used in this experiment. I shall briefly describe them in the order in which they occur in my records, writing the catalogue number before the description of them.

(477) This is a native Chinese cultivated pea, and was procured for me in a village not far from Pekin by Dr. Korsakov, of the Russian Legation in Pekin. *Wen-dou* is the name written on the packet in which they were sent. The peas are yellow and round. The pod and the peas themselves are very small, and have evidently not been imported from Europe during the last half century, if, indeed, there is any reason to suppose that they have been imported at all.

(478) This is one of a set of peas which my colleague, Mr. F. J. Bridgman, procured from a shipping merchant who was kind enough to put up a few packets of seeds from cargoes which had been shipped from various parts of the world. 478 was a particularly fine seed, resembling Victoria marrow, from a cargo which had been shipped from Germany.

(479) Nineteen seeds of this variety came into my possession at a meeting of the Natural History Society at the Royal College of Science during December, 1906. It is a small yellow round pea.

(480)	From Calcutta.	Through the same channel as 478. All yellow round.
(481)	From Canada.	
(482)	From Russia.	

(492) A yellow round pea which I bought in Genoa in April, 1906. The parents of the plants which were used in this experiment were grown in my garden in 1907. A yellow round pea.

(493) The same as 492, from a later sowing in 1907.

Explanation of Tables I—VIII.

Cross-pollination was effected in the following way:—A flower of suitable age was selected to function as pistil-parent; one side of its carina was torn transversely, the whole carina then temporarily slipped off the bunch of stamens, which were removed with forceps, after it had been determined that they had not yet dehisced. A flower of suitable age to function as pollen-parent was selected and plucked from the plant which bore it; the tip of its carina was cut off and the stigma of the pistil-parent was inserted into the aperture in the carina made by the cut, and consequently into the mass of pollen which it contained. The carina of the pistil-parent was then slipped back, and the standard and wings folded into their original position. The flower was then labelled. As a rule, I pollinated four flowers with the pollen of a single flower, in order to save time. When more than one flower has been pollinated from a single flower, this fact is indicated in Tables I and II by writing all the crosses made with the pollen of a single flower on the same line; except in cases in which different kinds of pistil-parents were fertilised from the same flower, when they are connected by a vertical bracket, as in crosses 121—124 (Table I).

The flowers of the pistil-parent were not enclosed in bags after they had been pollinated. I did not do this, because I had observed that bees did not visit the flowers until they were open, *i.e.*, a day or two after they had been pollinated. The neglect of this precaution was justified by the event. With a single exception, all the crosses which "took" proved successful, as could be determined in the autumn of the year in which the cross was made in the case of G♀ × Y♂, and in the following autumn in the case of Y♀ × G♂. The exception referred to occurred in a cross between *Wen-dou* and a pure green—*Express*, viz., cross No. 71 (Table II). When the pod containing the F_1 cotyledons was opened, it was found to contain four yellow and *one green* seed. This was presumably due to the fact that the flower functioning as pistil-parent was operated on a little too late.

All the crosses between the pure yellow and extracted green are recorded in Table I. Those which gave no seed are indicated by being printed in *italics*. The date at which the crosses were made is written against the first of the crosses made on a given date. Table II is a list of the (successful) control crosses, to be described later on (p. 69).

Tables III to VI give the numbers of yellows and greens in individual families composing F_2 from the cross between the yellow and the extracted green, and a summary of all the families composing this F_2 is given after Table VI. Tables VII and VIII give details of F_2 from the control crosses. When there was any doubt as to the colour of a seed, it was recorded as doubtful. The number of such seeds, if they occur, in each family* is given in the column headed with a ?. The families of F_2 cotyledons from the cross between the pure yellow and the extracted green are given in two lots, in one of which (Tables III, IV, and V) it has been possible to classify the families according to the green and also according to the yellow parent forms from which they have sprung, and in the other of which (Table VI) this classification has not been possible, owing to an accident. This occurred during harvesting. The plant or plants bearing the F_2 families from cross 166 were accidentally incorporated in a bundle with the plants from some other cross. I discovered this by finding the peg with 166 on it, after the day's harvesting, rather deep in the ground (the top was just covered), as I was hoeing. So that, knowing the mistake had occurred that day, I was able to know in which bundles 166 had been incorporated. If I had kept a record of the number of seeds I sowed from each cross, I should have been able to discover the plants bearing the F_2 from cross 166 during the process of recording; but I had not done this, in these particular sowings, partly because the ground had not been used for peas before (not in itself a sufficient justification), and partly because the seeds containing the F_1 cotyledons had been sown exactly 9 inches apart, so that if stray seeds *did* come up, they could not escape detection. (The rows were carefully examined during the process of weeding, which was done with great minuteness with the hand, the smallest seedlings being removed).† The families of F_2 cotyledons which cannot, as a result of this accident, be classified according to their yellow and green parent forms, have been given under a separate heading; but it must be understood that one of them (which, there is no means of discovering) contained an additional family borne on one or more plants. I tried to identify it by the general look of its seeds, but although the F_2 cotyledons produced from the different types of yellows are often strikingly like their yellow grandparents, I did not succeed. The only drawback, however, which this accident entails is the impossibility of employing these families for the purpose of determining the percentage of greens from crosses from the several green and yellow parent forms. The total result from the F_2 families not classifiable by parent forms has been incorporated in the grand total; as also has a plant which is recorded as having been "accidentally left behind between 216 and 28 and not belonging to either." There were 161 yellow and 50 green seeds on it (see Summary after Table VI). Fortunately, all the plants from crosses between the pure yellow and extracted green were grown on a plot by themselves, so that there can be no question as to the parentage of a plant like this.

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* By "family" I mean, in the present case, the number of peas on a plant.

† I have reorganised the method of carrying out my experiments in such a way that no further mistakes of this kind can occur.

The Percentages of Greens in F_2 *produced from the several Yellow and Green Parent-forms.*

I have classified all the F_2 families, from the cross between the pure yellow and extracted green, into groups according to their yellow grandparents, and also according to their green grandparents, where this was possible (see previous section), and have determined the proportions of greens in each of these groups with a view to finding out whether the close approximation to 25 per cent., viz., 24·88 per cent., which was the proportion of greens in the whole population (including those families which could not be classified into groups), was also exhibited in each of these groups. The percentage of greens, calculated from the total numbers of yellows and green in the classifiable families is 24·82. Now it is quite conceivable that this total proportion may be compounded of widely divergent proportions, ranging perhaps from 10 to 40 per cent., and each, possibly, characteristic of families from particular yellow or green grandparents. In order to find out whether the deviations which might be expected to, and do, occur, are significant, or attributable to chance, it is necessary to calculate the Probable Error of the percentage. Half the deviations should fall inside and half outside the Probable Error in the *plus* or *minus* direction; and deviations greater than four times the Probable Error should not occur often. The Probable Error of the ratio, expressed as a percentage, of any part to a whole (in this case the ratio of the greens in a generation to the total number of seeds in that generation) is calculated by the following formula, which I have used here:—

$$\frac{100\left[0{\cdot}67449\times\sqrt{a\left(1-\frac{a}{x}\right)}\right]}{x},$$

in which x is the whole (or the total number of seeds) and a is the part (or the number of greens). The table on the next page shows that of the

11 groups, 5 exhibit a deviation in a − direction, and 6 in a + direction. Also that 7 of the deviations (478, 479, 481, 482, 493, 483, and 484) fall within the Probable Error and 4 outside, in only one of which is the deviation greater than thrice the Probable Error—viz., in 480 in which the actual deviation is a little over three and a-half times the Probable Error. The application of this test, therefore, justifies us in concluding that the deviations from 25 per cent. which occur in each of these 11 groups are attributable to chance.

	Catalogue number* of grand-parent.	Number of yellows.	Number of greens.	Per-centage of greens.	Actual deviation of per-centage.	Probable Error of per-centage.
Classification by yellow grandparents	477	14,081	4,532	24·35	−0·65	±0·212
	478	7,172	2,405	25·11	+0·11	±0·299
	479	20,761	6,951	25·08	+0·08	±0·176
	480	3,978	1,224	23·53	−1·47	±0·397
	481	2,777	942	25·33	+0·33	±0·481
	482	11,140	3,715	25·01	+0·01	±0·240
	492	14,157	4,658	24·76	−0·24	±0·212
	493	1,408	486	25·66	+0·66	±0·677
Totals	—	75,474	24,913	24·82	−0·18	±0·092
Classification by green grandparents	483	38,565	12,788	24·9	−0·1	±0·129
	484	17,150	5,719	25·01	+0·01	±0·193
	485	19,759	6,406	24·48	+0·52	±0·179
Totals	—	75,474	24,913			

* For signification of these, see pp. 62 and 63.

The totals have been added up and written under the grouping by yellow grandparents and under the grouping by green grandparents. But the percentage of greens, the actual deviation and Probable Error of the percentage calculated from these totals, have only been written once, *i.e.*, under the grouping by yellow grandparents.

A Special Case.

In the F_2 families raised from five of the crosses there occurred wrinkled as well as round seeds. All these occurred in crosses made with the extracted green No. 484, which is the only one of the three races of extracted greens used, from which, on the Mendelian theory, wrinkled seeds could arise; for, as the table on p. 62 shows, neither of the other green rounds used occurred in a family in which wrinkleds also occurred.

The nature of the mating enclosed in brackets in the pedigree on p. 61 and of its subsequent progeny is of the type

RR × DD
DR
/ | \
RR DR DD

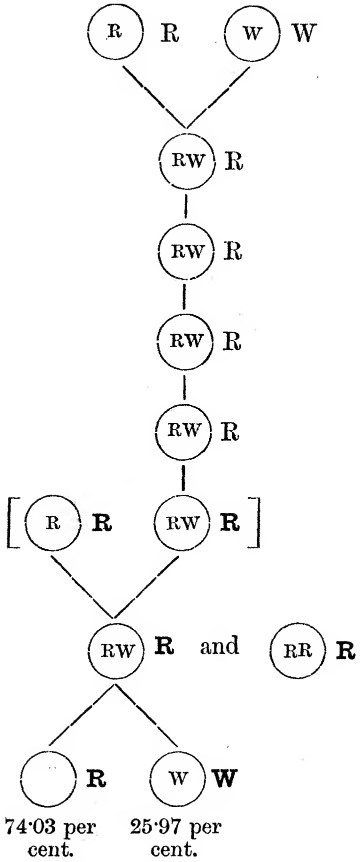
as far as the colour of the cotyledons is concerned. But with regard to the shape of the cotyledons, the nature of the mating, in those cases which gave wrinkleds in F_2, was of the type

DR × DD,

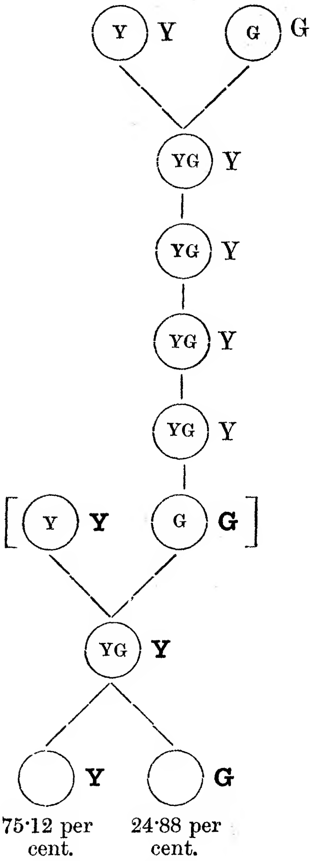
giving equal numbers of DR and DD individuals, the former of which, when allowed to self-fertilise, should produce rounds and wrinkleds in the proportion of 3 to 1. 14 families from 5 different crosses contained wrinkled seeds; in the case of 5 of these families I did not record the numbers of wrinkled, because I was not immediately alive to the interest of the case, and contented myself with recording the fact that both round and wrinkled did occur. In the remaining 9 families I recorded the numbers, and the totals were 2605 round and 914 wrinkled, which gives a percentage of 25·97 wrinkleds. Let us look for a moment at the ancestry, that is to say, the characters of the ancestors of this cross. The round hybrid, which gave rise to the F_2 in which this proportion of wrinkled occurred, was the result of the union of two *rounds,* one of them, the yellow, presumably a pure round, and the other, the extracted green, a hybrid round. This hybrid round was descended from an unbroken line of 4 "round" ancestors (each of them hybrids in the Mendelian sense); whilst behind that point half of the ancestors were round and half wrinkled. It will be convenient to display this ancestry in the form of a pedigree (Pedigree A), in which the crossing which gave rise to the F_2 in question is enclosed in a square bracket. Each ancestor is represented by a circle, and its character is written immediately to the right of the circle; the nature of the gametes borne by each ancestor being written within the circle.

Now let us write the pedigree on p. 61 out again (Pedigree B) in the same way as this, and compare the two (see p. 68).

The result obtained in F_2 from the experiment with cotyledon shape (Pedigree A) affords a more convincing *a posteriori* demonstration than that afforded by the experiment with cotyledon colour (Pedigree B), of the correctness of the course of leaving the soma out of account in the attempt to predict the result of a given mating. For, as is clearly seen by a



PEDIGREE A.



PEDIGREE B.

comparison of the two pedigrees, whereas in the case of cotyledon colour one of the parents of the hybrids, from the self-fertilisation of which the F_2 generation in question arose, bore the recessive character which reappeared in the proportion of 25 per cent. in that generation; in the case of cotyledon shape, *neither* of the parents exhibited the recessive character. Indeed, in the latter case the wrinkleds which appeared in F_2 had no ancestors bearing the wrinkled character for six generations behind them.

Subjoined are details of the families in which segregation into wrinkled and round occurred. Those in which I did not count the number of wrinkleds are simply marked DR. The families 158.1 to 6, and 175.1 to 4, fall into the unclassifiable group (see p. 64). They can, of course, be included in reckoning the percentage of greens in total of families in which segregation occurred, but not for calculating the relative numbers of families from DD and DR parents.

The actual deviation of the percentage of wrinkleds from expectation is +0·97; the Probable Error of this percentage is ±0·498: so that the actual deviation is just less than twice as great as the Probable Error, and is certainly not significant. Moreover, it is in the opposite direction to that which would afford any support to the theory of Ancestral Contributions.

	Number of family.	Nature of parent with regard to cotyledon colour.	Number of round.	Number of wrinkled.
Classifiable families	124. 1	DR	249	96
	124. 2	DR	219	64
	124. 3	DR	360	125
	165. 1	DR		
	165. 2	DD		
	165. 3	DD		
	165. 4	DR	393	142
	218. 1	DR	162	61
	218. 2	DR	408	147
	218. 3	DR	219	75
	218. 4	DD		
	218. 5	DD		
Unclassifiable families ...	158. 1	DD		
	158. 2	DR		
	158. 3	DR		
	158. 4	DR	297	103
	158. 5	DD		
	158. 6	DR	298	101
	175. 1	DR		
	175. 2	DD		
	175. 3	DR		
	175. 4	DD		
			2605	914

Percentage of greens .... 25·97
Probable Error of percentage ...... ±0·498

The number of families (falling into the categories classifiable by yellow and green grandparents) in which segregation occurred was 8; the number of families from the same parents in which segregation did not occur was 4. There should, on the Mendelian hypothesis, be equal numbers of the two (DR and DD give 50 per cent. DR, and 50 per cent. DD). But I do not think it desirable to base any conclusion on numbers so small as these.

Control Crosses.

The evidence on which the statement that the greens occur in the proportion of 25 per cent. in the F_2 generation from a cross between a pure yellow and a pure green pea is based, has been collected by Mr. Lock in his most useful paper on "The Present State of Knowledge of Heredity in

Pisum."* Subjoined is the table in which the details of this evidence are summarised by Mr. Lock. I give it in full because it embodies the result in F_2 from the cross made by Mr. Hurst, in F_5 from which the extracted greens which I used in my experiment occurred. The percentage of greens calculated from the total is 24·9. The actual deviation is less than the Probable Error.

Observer.	Yellow.	Green.	Green, per cent.
Mendel	6,022	2,001	24·9
Correns	1,394	453	24·5
Tschermak	3,580	1,190	24·9
Bateson	11,903	3,903	24·7
Hurst	1,310	445	25·4
Lock	1,438	514	26·2
	25,647	8,506	24·9

Besides the above, I have some evidence based on observations made by me which more strictly deserve to rank as control observations. This evidence is based on the result of crosses made between the identical yellow races used in the experiment, and, with the exception of the few crosses made in 1906, from the pollen from the identical crop of plants which were the yellow parents in the cross between the pure yellow and extracted (F_5) green (see Table II). The details of the F_2 families raised from these control crosses are given in Tables VII and VIII. The total number of yellows raised was 4015, and of greens 1394, the percentage of greens being 25·77. The Probable Error of the percentage is ±0·401, so that the actual deviation, being less than twice the Probable Error, is certainly not significant.

The expense of carrying out this experiment was defrayed by a grant from the Government Grant Committee of the Royal Society, and I take this opportunity of expressing my indebtedness to them. I also wish to express my thanks to Mr. Udny Yule and to Dr. E. Schuster for some preliminary statistical assistance, and to Mr. Charles Biddolph for clerical help.

Summary.

An experiment has been devised to test the truth of the theory of Ancestral Contributions: the results of the experiments prove:—

(*b*) That the recessive character which reappears in F_5 is as pure as that borne by a pure race, as tested by the results obtained from its union with a pure dominant character.

(*c*) That there is nothing like Ancestral Contributions within the limits of a single unit-character.

(*d*) That in the attempt to predict the result of a given mating the somatic characters not only of the parents and of the ancestors* of the individuals mated, but of the individuals themselves,† may be entirely left out of account; and that the expectation based on a theory of the contents of the germ cells of the two individuals mated is fulfilled.

SYNOPSIS OF CONTENTS OF TABLES AND SUMMARIES.

Those tables (viz., II, VII, and VIII) which embody the result of the control observations (see p. 70) are printed in italics.

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* See Pedigree B on p. 68.

† See Pedigree A on p. 68.

Table I.—Matings between Pure Yellows and Extracted Greens in F_5. (See pp. 61—65).

Number of cross or crosses.	Number of ♀ parent.	Number of ♂ parent.	Date of making cross (all 1907).
20, *21*	485	493	VI.2
22, 23	492	485	VI.9
24, 25, 26, 27, 28	485	492	
75, 76, 77, *78*	483	477	VI.16
79, 80, 81, *82*	483	477	
83, 84, 85, 86, 87	483	492	
88, 89, *90*, 91	485	492	
108, 109, *110*, 111	477	483	
112	483	477	
113, 114, 115, 116	483	477	VI.22
117, *118*, 119, 120	483	477	
121	483	479	
122, 123, 124	484	479	
125, 126, 127, 128	485	479	
129, 130, 131, 132	485	492	
143, 144, 145, *146*	483	479	VI.26
147, 148, 149, 150	483	479	
151, 152, 153, 154	483	479	
155, 156, *157*, 158	484	479	
159, *160*, 161, 162	483	492	
163, 164	483	480	
165, 166†	484	480	
167, *168*, *169*, 170	484	481	
171, 172, *173*, 174	484	477	
175, *176*, 177, 178	484	478	VI.29
179, 180, 181, 182	483	479	
183, 184, 185, 186	483	480	
187, 188, 189, 190	485	492	
191, 192, 193, 194, 195, 196	484	479	
205, 206	483	477	VII.1
217, 218	484	493	
223, 224	485	482	VII.2
225, *226*	484	482	
227, 228	478	484	
229, *230*	485	478	VII.6
231	484	478	
232, 233, *234*, 235	478	483	
236, 237, 238, 239	482	483	
240	483	479	VII.7
241, 242, 243	485	479	
263, *264*, 265, 266	482	483	
267, 268, *269*, 270	482	485	
271, 272, 273	485	494	
274, 275, *276*, *277*	481	484	VII.14

* See p. 64.

Note.—The association of crosses (such as 129 and 130) by a horizontal bracket indicates that the two stigmas pollinated were in flowers on the same peduncle.

Table II.—Matings between Pure Yellows and Pure Greens. (See p. 70.)

Number of cross or crosses.	Number of ♀ parent.	Number of ♂ parent.	Date of making cross.
1906 29	329	404	VI.10
31, 32	323	404	
1907 40	477	491	VI.9
44	477	491	
69, 70, 71*	491	477	VI.10
97, 98, 99	480	491	VI.16
104, 105	491	477	
200	491	479	VI.29
204	491	477	
208	491	479	VII.1
210	491	477	
244	491	479	VII.7
250	491	477	
252, 254, 255	491	478	
256	491	480	
258, 259	491	481	
260, 261	491	482	

* See note on p. 64.

Note.—The significations of the numbers indicating the parents in the 1907 crosses will be found on p. 63. The following are the parents of the 1906 crosses (the first three on the list):—323 = "Express" (green round); 329 = Laxton's "Alpha" (green wrinkled); 404 is the 1906 sowing of the yellow round type which appears as 492 and 493 in the 1907 crosses (see p. 63).

Details of F_2 Families, produced from Crosses in Table I, classifiable by Yellow and Green Grandparents.

Table III.—Particulars of F_2 Families from Crosses made with Extracted Green No. 483.

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
75. 1	146	52		77. 4	13	11		85. 1	74	26	
75. 2	82	20		77. 5	103	37	3	85. 2	73	28	
75. 3	172	55	2	79. 1	107	31		85. 3	138	43	2
75. 4	142	42	1	79. 2	96	30		86. 1	203	54	
75. 5	149	50	4	79. 3	32	10		86. 2	157	58	
75. 6	160	63	1	79. 4	129	41		86. 3	103	48	
75. 7	24	14		79. 5	172	47		86. 4	85	31	
76. 1	196	68	1	81. 1	38	22		87. 1	38	9	
76. 2	133	41		81. 2	153	54		87. 2	73	27	
76. 3	64	27		81. 3	190	52		87. 3	71	27	1
76. 4	118	36		81. 4	152	52		87. 4	122	44	1
76. 5	283	95	2	81. 5	141	44	2	87. 5	173	57	
76. 6	100	31		81. 6	63	26		87. 6	83	32	
76. 7	114	34	1	83. 1	95	36		108. 1	360	114	2
76. 8	158	48		84. 1	31	18		108. 2	343	115	
77. 1	8	2		84. 2	67	23		109. 1	41	15	
77. 2	52	12		84. 3	50	17		109. 2	174	58	3
77. 3	69	21		84. 4	122	38		109. 3	36	16	

Table III—*continued.*

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
109. 4	33	13		144. 1	40	12		186. 2	300	97	
109. 5	66	15		144. 2	20	9		186. 3	216	57	1
109. 6	41	10		144. 3	249	77	1	195. 1	184	58	
112. 1	18	15		148. 1	361	103	1	195. 2	231	85	
112. 2	343	93		148. 2	266	98	3	195. 3	181	65	
112. 3	241	77		148. 3	19	5		195. 4	169	63	
112. 4	163	43		148. 4	175	78		206. 1	346	115	3
112. 5	129	39		152. 1	349	120	5	206. 2	173	68	
113. 1	132	47		152. 2	286	95	6	206. 3	608	201	6
113. 2	149	56		152. 3	194	58	3	206. 4	103	39	
113. 3	75	26	4	153. 1	118	48	4	232. 1	528	180	1
113. 4	115	45		153. 2	56	20		232. 2	229	84	2
113. 5	124	40		153. 3	53	8		232. 3	241	84	2
113. br.*	38	15		153. 4	97	27	3	233. 1	224	86	
114. 1	86	22	1	154. 1	270	93	3	233. 2	224	76	
114. 2	172	68		154. 2	158	46		233. 3	164	64	
114. 3	159	45	2	154. 3	190	66	3	233. 4	221	79	1
114. 4	279	84	4	154. 4	265	80		233. 5	79	24	
114. 5	119	52		154. 5	307	96		233. 6	201	75	
114. 6	130	45	1	159. 1	91	28		233. 7	59	18	
114. 7	169	44		159. 2	138	55		233. 8	76	39	1
115. 1	123	36		159. 3	169	42		235. 1	173	57	
115. 2	135	54		159. 4	265	83		235. 2	203	57	
115. 3	176	58	3	161. 1	360	103	2	235. 3	99	26	
116. 1	154	50		161. 2	176	69	3	235. 4	127	47	
117. 1	376	110		161. 3	290	78	8	235. 5	206	61	6
117. 2	257	97	2	162. 1	156	56		235. 6	139	36	
117. 3	305	98	2	162. 2	167	65	5	237. 1	483	200	1
119. 1	246	72	2	162. 3	295	110	2	237. 2	364	125	2
119. 2	150	43		162. 4	155	48		238. 1	378	127	1
119. 3	72	22	1	162. 5	212	71	1	238. 2	430	134	3
119. 4	30	6		162. 6	159	66	1	240. 1	321	102	4
119. 5	317	93	6	164. 1	150	56	2	240. 2	299	98	
119. 6	375	127	3	164. 2	286	68	4	240. 3	127	37	
120. 1	161	53		164. 3	151	45		240. 4	263	110	
120. 2	87	32	1	164. 4	194	59	2	240. 5	267	76	
120. 3	127	46		164. 5	55	15		265. 1	165	59	
120. 4	121	25		164. 6	247	81	2	265. 2	291	74	
120. 5	209	64	5	164. 7	222	62	6	265. 3	408	123	5
120. 6	250	68	1	164. 8	263	91	10	265. 4	449	138	3
121. 1	198	65		164. 9	119	35	8	265. 5	296	98	
121. 2	288	97		179. 1	334	112	3	265. 6	204	67	
121. 3	253	97	1	179. 2	481	157	8	265. 7	429	184	2
121. 4	244	79		179. 3	285	108		266. 1	355	128	3
121. 5	324	94	1	179. 4	442	163		266. 2	403	116	6
121. 6	379	131		179. 5	391	152	1	266. 3	25	6	
121. 7	45	10		179. 6	504	181		266. 4	465	152	1
121. 8	362	109	2	179. 7	387	142	1	266. 5	202	64	1
143. 1	191	56		186. 1	234	72		266. 6	379	129	3

* A branch.

Table IV.—Particulars of F_2 Families from Crosses made with Extracted Green No. 484.

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
124. 1	260	85	4	191. 2	253	102	1	225. 2	134	44	
124. 2	205	78	2	191. 3	310	103	2	225. 3	339	108	1
124. 3	378	107	1	192. 1	269	89	2	227. 1	132	51	2
156. 1	279	96		192. 2	311	109	1	228. 1	207	58	5
156. 2	419	125		192. 3	497	175		228. 2	100	37	1
156. 3	311	90		192. 4	408	144	1	228. 3	165	52	1
165. 1	546	168	3	193. 1	72	22		228. 4	207	54	
165. 2	226	79	6	193. 2	270	87	1	228. 5	206	63	1
165. 3	353	120		193. 3	318	126	2	228. 6	271	85	5
165. 4	416	119	2	194. 1	215	79	1	228. 7	245	89	1
172. 1	436	112		194. 2	108	37		231. 1	133	40	
172. 2	273	84		194. 3	166	48	3	231. 2	108	36	
172. 3	81	17	1	194. 4	34	7		231. 3	378	151	1
172. 4	265	92	1	194. 5	168	65	6	274. 1	439	141	3
172. 5	316	99	1	194. 6	125	34	1	274. 2	334	88	
174. 1	278	97		218. 1	165	58	10	275. 1	326	108	
174. 2	237	74		218. 2	422	133	2	275. 2	342	127	
178. 1	239	98	2	218. 3	213	81	3	275. 3	179	73	
178. 2	150	48	2	218. 4	514	178	4	275. 4	399	153	1
178. 3	339	114	4	218. 5	94	36		275. 5	375	127	
178. 4	176	58	1	225. 1	380	154	1	275. 6	383	125	
191. 1	253	82	2								

Table V.—Particulars of F_2 Families from Crosses made with Extracted Green No. 485.

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
22. 1	86	35		91. 3	388	128	1	188. 1	165	45	
22. 2	28	11		91. 4	271	86	1	188. 2	172	59	
22. 3	118	43		125. 1	83	28	1	188. 3	192	72	
22. 4	138	30		126. 1	72	31		188. 4	195	64	
22. 5	205	65	1	127. 1	371	112	3	190. 1	14	1	2
22. 6	220	59	1	127. 2	354	114	1	190. 2	25	4	
22. 7	206	71		127. 3	257	98		190. 3	82	19	3
23. 1	33	12		127. 4	273	94	1	223. 1	255	83	2
23. 2	174	50		127. 5	370	123		223. 2	434	142	6
23. 3	78	21		127. 6	257	88		223. 3	264	82	3
23. 4	230	64		128. 1	262	77		223. 4	411	128	4
23. 5	112	44		128. 2	394	137		229. 1	270	88	
24. 1	213	78		128. 3	297	100		229. 2	202	56	
24. 2	206	66	1	128. 4	270	75	2	229. 3	137	37	
25. 1	129	35		128. 5	328	113		229. 4	314	97	
25. 2	97	42		128. 6	337	107		242. 1	129	43	
26. 1	282	109		128. br.	51	16		242. 2	26	4	
26. 2	155	54	1	129. 1	216	70		242. 3	113	31	1
26. 3	237	87	1	129. 2	275	89	5	242. 4	265	84	
26. 4	123	52		130. 1	295	78		267. 1	85	28	
28. 1	153	45	2	130. 2	89	35	2	267. 2	412	122	1
28. 2	96	38		130. 3	269	88	2	267. 3	212	73	1
88. 1	123	40		130. 4	65	10		267. 4	234	84	1
88. 2	34	10		130. 5	227	80	3	267. 5	179	58	
88. 3	255	56		131. 1	268	87	3	267. 6	267	101	
88. 4	209	55		131. 2	341	122	6	268. 1	29	5	1
88. 5	123	36	1	132. 1	153	45		268. 2	79	24	5
88. 6	91	20		132. 2	71	27	1	270. 1	407	118	3
89. 1	186	51	2	132. 3	157	52	1	270. 2	133	46	
89. 2	149	53	1	132. 4	225	75	11	270. 3	414	155	5
89. 3	33	17		132. 5	260	88	7	270. 4	320	107	4
89. 4	156	55	1	187. 1	88	33		270. 5	22	10	
91. 1	197	64		187. 2	187	71	4	270. 6	404	119	2
91. 2	201	72									

Table VI.—Particulars of F_2 Families, from Crosses between Pure Yellow and Extracted (F_5) Greens, not Classifiable by Yellow and Green Grandparents.

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
27. 1	194	68	1	170. 3				189. 3	253	67	1
27. 2	141	49		and	382	123	1	189. 4	200	74	
80. 1	169	56		170. 4*				189. 5	146	57	4
80. 2	133	35	1	170. 5	291	91	1	189. 6	21	9	
80. 3	111	29		175. 1	75	26		189. 7	247	74	2
111. 1	237	70	3	175. 2	153	49		196. 1	459	170	5
123. 1	518	175	7	175. 3	138	34		196. 2	271	91	6
123. 2	216	74	1	175. 4	263	99		196. 3	194	50	1
123. 3	333	126	3	177. 1	205	76		196. 4	270	91	3
123. 4	295	106	7	177. 2	248	70		196. 5	122	38	
123. 5	386	124	2	177. 3	251	92		196. 6	150	49	1
123. br.	36	16		180. 1	178	53	1	196. br.	12	1	1
145. 1	228	71	3	180. 2	325	109	3	205. 1	117	34	
145. 2	132	35	2	180. 3	283	106	3	205. 2	146	37	1
145. 3	147	59		180. 4	264	89		205. 3	261	97	
145. 4	174	57		180. 5	226	64	2	205. 4	335	118	1
145. 5	214	69	5	181. 1	134	43	3	205. 5	265	71	
145. 6	311	121		181. 2	457	163	5	224. 1	463	144	3
145. 7	82	27		182. 1	212	61	3	224. 2	71	27	
145. 8	260	106	1	182. 2	292	114	4	224. 3	455	143	1
149. 1	251	87	7	182. 3	290	92		224. 4	447	186	
149. 2	490	165	12	182. 4	126	51		239. 1	232	73	1
149. 3	192	50	5	182. 5	278	79	4	239. 2	105	24	
149. 4	326	109	5	182. 6	351	127		239. 3	490	167	
149. 5	176	42	6	182. 7	406	128	3	239. 4	323	96	1
149. 6	309	106	11	183. 1	233	70	2	239. 5	136	42	
150. 1	225	75	1	183. 2	164	62		239. br.	73	26	
155. 1	318	110		183. 3	158	46	1	241. 1	388	126	2
155. 2	516	201		183. 4	16	7		241. 2	312	106	1
158. 1	282	109		183. 5	117	39		241. 3	119	39	
158. 2	132	47		183. 6	234	74	3	241. br.	25	9	
158. 3	146	40		184. 1	254	89	2	243. 1	186	70	1
158. 4	296	104		184. 2	346	108	1	243. 2	153	53	
158. 5	268	88		185. 1	283	94	2	243. 3	189	66	
158. 6	304	95		185. 2	350	106		243. 4	204	83	
167. 1	359	128		185. 3	309	87		271. 1	192	68	
167. 2	270	93		185. 4				271. 2	243	69	2
167. 3	519	203	1	and	560	185	2	271. 3	186	73	
167. 4	314	86		185. 5*				272. 1	269	96	2
170. 1	416	133	2	185. 6	270	112		272. 2	259	66	1
170. 2	138	48	1	189. 1	164	52		272. 3	133	57	
				189. 2	19	7		273. 1	419	123	

* By an accident the two families bracketed were recorded together.

NOTE.—A glance at Tables III to VI (Experimental F_2) on the one hand, and at VII and VIII (Control F_2) on the other is, alone, sufficient to reveal an enormous difference in the average size of the family, *i.e.*, in the average number of seeds on a plant, in these two groups. The superiority of the former group is due to the fact that the seeds which gave rise to the plants recorded in it were sown 9 inches apart, that the plot on which the plants grew was dug two spits deep, a heavy dressing of stable manure being thrown on to the top of the lower spit; whereas the plot on which the Control F_2 families (those recorded in Tables VII and VIII) was only dug one spit deep and received no manure, except a dressing of superphosphate of lime and steamed bone-flour which was also given to the other plot. I have evidence, as yet unpublished, that the proportion of yellow and green seeds is *not* affected by the nutrition of the plant.

Summary of F_2 Families from Crosses between Pure Yellows and Extracted (F_5) Greens.

	Yellow.	Green.
Table III	38,565	12,788
„ IV	17,150	5,719
„ V	19,759	6,406
„ VI	29,410	9,829
Family referred to on p. 65	161	50
Totals	105,045	34,792

Percentage of green	24·88
Actual deviation	−0·12
Probable Error of percentage	±0·078

Table VII.—Particulars of F_2 Families from Control Crosses made in 1906.

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
29. 1	108	29		31. 4	103	33		32. 4	46	18	
29. 2	95	22		32. 1	22	9		32. 5	72	25	
31. 1	73	26		32. 2	60	19		32. 6	70	23	
31. 2	227	78		32. 3	76	27		32. 7	110	31	
31. 3	84	19									

NOTE.—For details of parentage, see Table II.

Table VIII.—Particulars of F_2 Families from Control Crosses made in 1907 between the Pure Yellow Types used in the Experiment and "Express" a Pure Green (Round) Type.

Number of family.	Y.	G.	?	Number of family.	Y.	G.	?	Number of family.	Y.	G.	?
40. 1	24	12		105. 1	12	2		255. 2	32	19	
40. 2	52	13		105. 2	12	3		255. 3	64	19	
40. 3	49	17		105. 3	38	14		255. 4	27	7	
40. 4	11	4		105. 4	40	12		255. 5	31	10	
40. 5	49	20		105. 5	18	8		255. 6	20	14	
44. 1	12	4		105. 6	24	6		255. 7	45	18	
69. 1	15	6		200. 1	22	7		256. 1	34	9	
69. 2	9	6		204. 1	44	14		256. 2	61	16	1
69. 3	23	8		204. 2	28	16	2	256. 3	33	22	
69. 4	2	2		208. 1	23	7		256. 4	37	11	2
69. 5	30	11		208. 2	18	6		256. 5	52	20	1
70. 1	23	7		208. 3	48	16		258. 1	34	22	
70. 2	7	1		210. 1	15	8		258. 2	15	8	
70. 3	41	16		210. 2	32	6		258. 3	7	4	
71. 1	2	1		244. 1	39	13	2	258. 4	43	15	
71. 2	45	14		244. 2	7	5		259. 1	3	2	
97. 1	1	—	1	244. 3	64	24		259. 2	8	1	
97. 2	24	10		250. 1	8	4		259. 3	14	2	
97. 3	52	19		250. 2	26	11		259. 4	35	11	
98. 1	40	9		250. 3	34	18		260. 1	87	27	
98. 2	51	14	1	250. 4	17	8		260. 2	21	6	
99. 1	86	39		250. 5	5	2		260. 3	26	7	
104. 1	15	10		252. 1	43	11		260. 4	69	20	
104. 2	29	12		252. 2	29	19		260. 5	24	8	
104. 3	58	20		254. 1	25	8		261. 1	7	2	
104. 4	9	2		254. 2	31	16		261. 2	104	32	
104. 5	29	11		254. 3	25	12		261. 3	74	22	
104. 6	18	7		254. 4	88	31		261. 4	51	14	
104. 7	28	13		255. 1	53	15		261. 5	109	37	

NOTE.—For details of parentage, see Table II.

Summary of F_2 Families from Control Crosses.

	Yellow.	Green.
Table VII	1146	359
„ VIII	2869	1035
Totals	4015	1394

Percentage of green .... 25·77
Actual deviation .... +0·77
Probable Error of percentage .... ±0·401